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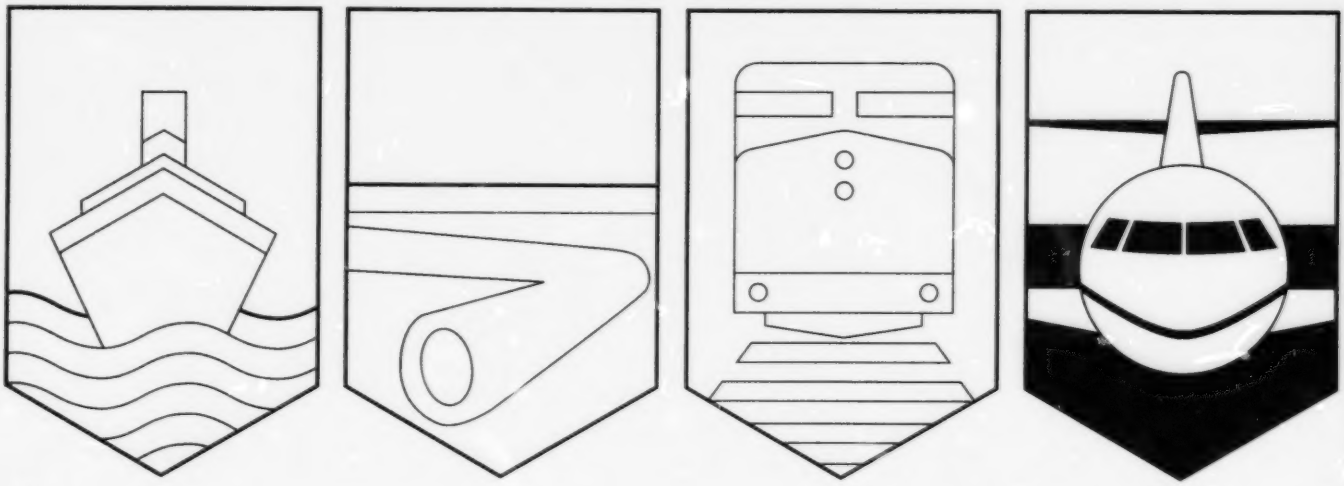
Transportation Safety Board of Canada



AVIATION OCCURRENCE REPORT

VOYAGEUR AIRWAYS LTD
BEECHCRAFT KING AIR A-100 C-GJUL
CHAPLEAU, ONTARIO
29 November 1988

REPORT NUMBER 88O0491

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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SYNOPSIS

The air ambulance Beechcraft King Air A-100, Voyageur 796, with two flight crew members and two paramedics on board, departed Timmins for Chapleau, Ontario on an instrument flight rules (IFR) flight. There, a seriously injured person was to be boarded and flown to Sault Ste. Marie, Ontario. The aircraft proceeded from Timmins en route at 12,000 feet, and, on arrival at Chapleau, the aircraft overflew the airport at low altitude and crashed 1.5 miles southwest of the airport. The four occupants were fatally injured, and the aircraft was destroyed by the impact and post-impact fire.

The Transportation Safety Board of Canada determined that the flight crew descended below the minimum applicable IFR altitude while approaching the Chapleau non-directional beacon. It could not be determined why the crew allowed the aircraft to descend, in controlled flight, into the ground.

12 February 1991

Ce rapport est également disponible en français.

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

The air ambulance Beechcraft King Air A-100, Voyageur 796, with two crew members and two medical attendants on board, departed Timmins, Ontario at 2229 eastern standard time (EST)* on an instrument flight rules (IFR)** flight to Chapleau, Ontario. There, a seriously wounded person was to be boarded and transferred to Sault Ste. Marie, Ontario. The flight was designated as a Code 4, the highest classification of medical evacuation (MEDEVAC) flight. The flight proceeded from Timmins at an altitude of 12,000 feet above sea level (asl)*** to Chapleau, and when the aircraft was 26 nautical miles (nm) from Chapleau, the crew commenced their descent to the airport.

The Chapleau Airport manager, who was expecting the air ambulance flight, heard the aircraft flying low over the airport and radioed the crew. A crew member responded and indicated that they were heading toward the Chapleau non-directional beacon (NDB) and requested "the numbers". The word "numbers" was cut short, and no other radio transmissions were heard. A local resident was walking in the vicinity when he heard the aircraft fly low overhead, then heard an explosion. He then saw an orange fire-ball which lasted approximately five seconds. He reported what he had heard to the Chapleau Airport manager, who then notified Air Traffic Services. The aircraft crashed in a densely wooded area 1.5 nm southwest of the airport. The four occupants were fatally injured.

The accident occurred at 2301 EST, during the hours of darkness, at 47°49'N latitude, 83°22'W longitude, at an elevation of 1,590 feet asl.

* All times are EST (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.

** See Glossary (APPENDIX D) for all abbreviations and acronyms.

*** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

1.2 Injuries

	Crew	Passenger	Other	Total
Fatal	2	2	-	4
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	2	2	-	4

1.3 Damage to Aircraft

The aircraft was destroyed by the impact, and the fuselage area was consumed by a post-impact fire.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Captain	Co-Pilot
Age	27	25
Pilot Licence	Airline Transport	Commercial
Medical Expiry Date	01 June 1989	01 October 1989
Total Flying Time	3,131 hr	1,600 hr
Total on Type	543 hr	147 hr
Total Last 90 Days	158 hr	167 hr
Total on Type Last 90 Days	49 hr	147 hr
Hours on Duty Prior to Occurrence	10 hr	3 hr
Hours off Duty Prior to Work Period	18 hr	21 hr

1.5.1 Background of the Captain

The captain was qualified and held a valid licence. He started flying for Voyageur Airways in May 1987 and had been based in Sioux Lookout, Ontario as an air ambulance pilot since September 1987. He was promoted to Senior Base Pilot at Sioux Lookout in March 1988 and was also qualified to act as captain on the Beech King Air 200C, the other air ambulance aircraft based at Sioux Lookout. The captain had accumulated a total of 540 hours on the Beech King Air 200C of which 109 hours had been accrued in the last 90 days.

The captain's most recent pilot proficiency check (PPC) and instrument rating renewal ride were conducted on 29 September 1988 and 30 March 1988 respectively. In both cases he demonstrated good aircraft knowledge and good aircraft handling.

There were no indications that the captain had previously flown into or out of Chapleau Airport; however, he was familiar with flight operations into other similar northern Ontario airports. The captain was experienced in multi-crew flight operations, but he had not previously flown with the co-pilot.

The captain was known to occupy the front left seat. It could not be established if the captain was at the controls of the aircraft at the time of the accident. The captain was heard making radio transmissions during the flight from Timmins to Chapleau. In a multi-crew flight operation, radio transmissions are normally made by the pilot not flying.

The captain was well known and respected within the company. He was not known to push the weather, nor was he considered likely to compromise safety standards because of a Code 4 medical evacuation. His peers reported that, both as a captain and as a senior pilot, he would make good decisions under pressure. He was also known to do things in accordance with established procedures. Other company pilots indicated that he rarely used the autopilot, especially below 10,000 feet asl.

1.5.2 Captain's Activities Prior to the Accident

On the day of the accident, Voyageur Airways assumed responsibility for the Ontario Ministry of Health Air Ambulance service based in Timmins. The change-over in responsibility from the previous contractor occurred at 1900 EST. Voyageur Airways had decided that the Beech King Air A-100, based in Sioux Lookout, would be temporarily transferred to Timmins to fulfill the Air Ambulance commitment.

The captain departed Sioux Lookout, Ontario at 1426 EST in the accident aircraft, arriving in Timmins after a two-hour flight. The captain then reported for duty in Timmins at 1900 EST for the start of what was to be a six-hour shift. Because he did not have a sufficient rest period between the flight from Sioux Lookout and the commencement of his stand-by duty, Voyageur Airways intended that he be replaced on duty by another captain halfway through the normal 12-hour shift. The captain had been off duty for 18 hours prior to reporting for duty the day of the accident and was observed to be in an alert and positive state of mind when he commenced his stand-by duty. Prior to the commencement of the shift, he checked the equipment on the aircraft and familiarized the paramedics with the aircraft layout.

1.5.3 Background of the Co-Pilot

The co-pilot was qualified and held a valid licence. He commenced flying with Voyageur Airways in September 1988 and was based at the company's main base in North Bay, Ontario. He had previously worked as an IFR flight instructor at a flying club in New Brunswick. On 29 September 1988, he successfully completed a PPC and was assigned to co-pilot duties on the Beech A-100.

On the day of the accident, the co-pilot left North Bay in the late afternoon to arrive at Timmins for the start of his 12-hour shift at 1900 EST. He was to remain there for two days and then return to North Bay. He was reported to be in an alert and positive state of mind when he commenced his stand-by duties. It was determined that the co-pilot had never flown into Chapleau Airport prior to the accident.

1.5.4 Paramedics

Both paramedics had been based in Timmins for two years, and each held a paramedic certification with the Ontario Ministry of Health (MOH). They had completed a check-out on the aircraft with the captain prior to commencement of the stand-by duty.

1.6 Aircraft Information

Manufacturer	Beech Aircraft Corp.
Type	King Air A-100
Year of Manufacture	1975
Serial Number	B-218
Certificate of Airworthiness	Valid
Total Airframe Time	9,420 hr
Engine Type (2)	Pratt & Whitney PT6A-28
Propeller Type (2)	Hartzell HC-B4TN-3A Constant Speed - Fully Feathering
Maximum Allowable Take-off Weight	11,500 lb
Recommended Fuel Types	Jet A, Jet A1, Jet B

According to the aircraft technical log-books, maintenance had been carried out as prescribed, and there were no reported deficiencies outstanding against the aircraft prior to the accident flight. The captain had flown the aircraft from Sioux Lookout to Timmins the day of the accident and had reported no difficulties or unserviceabilities on his arrival in Timmins. The aircraft journey log was recovered from the wreckage, and there were no entries outstanding, nor were any made during the accident flight.

The aircraft was equipped with an altitude alert system which generates an aural tone and an illuminated light when the aircraft approaches or deviates from the selected altitude. The aircraft was also equipped with a radar altimeter which measures the vertical distance between the aircraft and the terrain immediately below it. It incorporates a cockpit display which includes a movable alert pointer that could be set to specific height above terrain. When the aircraft height above terrain is at or below the set height, a light would illuminate on the instrument display.

1.6.1 Weight and Balance

The aircraft was refueled in Timmins before the flight. No weight and balance document for the accident flight was found; however, the take-off weight was calculated to be 10,954 pounds, or 546 pounds under the maximum allowable take-off weight of 11,500 pounds. At the time of the accident, the aircraft weight was estimated to be at 10,500 pounds. The centre of gravity was calculated to be within the prescribed limits.

1.7 Meteorological Information

On 29 November 1988, the Timmins-Chapleau region was under the influence of a low pressure system located across Lake Michigan and an associated trough extending northward from the low. An Arctic wave accompanied this system. The wave was located just west of Wawa, with a warm front extending southeastward through the Ottawa valley.

The area forecast for the Superior, Sudbury and Cochrane regions valid for the period 1900 EST, 29 November to 0700 EST, 30 November predicted overcast, occasionally broken, cloud ceilings at 2,000 feet above ground level (agl) topped at 5,000 feet, with layers to 15,000 feet, and light snow showers. Additionally, for the Sudbury and southern Cochrane regions, visibility was forecast to be three to five miles in light snow with isolated areas of snow ceilings 200 to 800 feet and visibility one-half to three miles in light snow and fog. The terminal forecast for the Chapleau Airport, valid from 1800 to 2100 EST, predicted an overcast ceiling 1,500 feet agl in light snow, with an occasional partially obscured broken ceiling at 500 feet with visibility one-half mile in light snow and fog.

The weather during the evening was characterized by a layer of low cloud based between 700 and 1,200 agl, with a gentle southeasterly flow. Snow spread

northeastward across the region, reaching Chapleau at about 2000 EST.

No weather observations are available for Chapleau after 2100 EST. The last official weather observation for Chapleau, taken at 2100 EST, reported broken cloud measured at 1,000 feet, visibility eight miles in light snow, temperature minus 12 degrees Celsius, dew point minus 13 degrees Celsius, winds from 350 degrees true at five knots, and altimeter setting 29.85 inches of mercury (in. Hg).

The Chapleau Airport manager, although nct a qualified weather observer, stated that at the time of the accident, there were light snow showers, the wind was blowing from 190 degrees true at seven knots, and the altimeter setting was 29.76 in. Hg. The local resident who heard the aircraft crash and observed the post-crash fire-ball reported that, at the time of the accident, it was snowing and visibility was reduced.

A weather observation taken after the accident at 0110 EST indicated scattered to broken cloud varying from 700 to 800 feet agl and visibility ranging from two to four miles in light snow.

One of the flight crew members received a weather briefing from a specialist at the Timmins Flight Service Station (FSS) after the beginning of the stand-by duty period. The briefing included an overview of the central and northern Ontario weather as it was expected to develop during the night. At the time of the request for the MEDEVAC from Chapleau, shortly before 2200 EST, the latest and last weather observation for Chapleau was less than one hour old.

1.8 Aids to Navigation

The Timmins very high frequency omni-directional range (VOR), which operates on frequency 113.0 megahertz (MHz), serves air route Alpha Romeo 16 (AR16). AR16 joins the Timmins VOR to the Chapleau NDB, which operates on frequency 335 kilohertz (kHz) (see APPENDIX A). The Timmins VOR is collocated with distance measuring equipment (DME) which provides distance measuring capabilities along the 250 degree track for AR16. The Timmins NDB, which operates on frequency 212 kHz, also serves the air route. The distance between the Timmins VOR and the Chapleau NDB is 95 nm. The published minimum enroute altitude (MEA) for AR16 is 3,000 feet asl.

In addition to being an en route navigation aid, the Chapleau NDB also serves as an approach facility to Chapleau Airport and is located 4.3 nm southwest of runway 05; the accident site was between the airport and the Chapleau NDB. The Sault Ste. Marie FSS continuously monitors the operation of this NDB.

No unserviceability of any of these navigation facilities was reported during the period of the flight.

1.9 Communications

During the flight, the captain was in very high frequency (VHF) radio communication with the Timmins FSS, North Bay Terminal Control and Toronto Centre Control. All communications were normal. Additional radio equipment on board the aircraft allowed the pilots and medical attendants to communicate on VHF, VHF-FM, ultra-high frequency (UHF) and mobile satellite L-Band frequencies operated by the MOH Air Ambulance dispatch communication system. An attempt by the captain to contact the MOH Timmins dispatch on the MOH VHF frequency approximately 12 minutes into the flight was only partly successful and was terminated after the captain advised that the attendants could not hear the radio transmission.

At 2252 EST, Voyageur 796 was cleared out of controlled airspace and instructed to contact the Chapleau Aerodrome Traffic Frequency (ATF).

The Chapleau Airport manager reported that he was advised by telephone of the MEDEVAC flight at about 2130 EST and proceeded to the airport shortly after 2200 EST. Upon arrival, he switched on the runway and airport lights and conducted an inspection of the runway. He then returned to the terminal building to await a radio call from the inbound aircraft on the Chapleau ATF. No radio call was received.

At approximately 2300 EST, the airport manager reported hearing an aircraft overfly the airport at a low altitude. The manager reported that he queried the aircraft by calling on the ATF, "aircraft over Chapleau, this is Chapleau UNICOM". The aircraft responded with, "Voyageur King Air, going to beacon and give me your numbers". The word "numbers" was reported to be cut off. There was no further contact with Voyageur 796. The airport manager reported that there was nothing in the tone of the pilots' voices to suggest an abnormal condition in the aircraft. The Chapleau ATF is not recorded. No other radio

communications between the aircraft and any other agency are known to have occurred.

1.10 Aerodrome Information

Chapleau Airport is located 2.5 miles southeast of the town of Chapleau at 47°49'N latitude, 83°21'W longitude. The airport reference altitude is 1,465 feet asl. The airport is publicly licensed and is operated by the Township of Chapleau. The two asphalt surface runways are designated 10/28 and 05/23. Runway 10/28 is 4,000 feet long and 100 feet wide; runway 05/23 is 3,000 feet long and 75 feet wide. The runways are equipped with low-intensity runway edge lights and threshold lights. Before the aircraft overflew the airport, the airport manager reported that he switched on the lights for runway 05/23, the airport rotating beacon, and the lighted wind direction indicator. One of the two lights in the airport rotating beacon was found burned out after the accident.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation.

1.12 Wreckage and Impact Information

1.12.1 General

The aircraft struck terrain 1.5 miles southwest of the airport, about two miles to the northwest of AR16 and on the direct track between the airport and the Chapleau NDB. The terrain elevation at the accident site was 1,590 feet asl.

The area between the airport and the accident site is gently rolling terrain covered with trees averaging 50 feet in height. The aircraft initially struck the tree tops in a wings-level attitude at a descent angle of less than five degrees. The angle through the trees increased to approximately 30 degrees as the aircraft broke up and struck the ground. The main wreckage, which consisted of a large section of the fuselage and a small section of the left wing, came to rest in an inverted position, 750 feet from the initial tree strike. The wreckage was scattered along a trail 650 feet long and from 25 to 40 feet wide. The heading of the wreckage trail was 212 degrees magnetic, the general direction from the airport to the Chapleau NDB.

The aircraft was fitted with a Saunders spar strap which remained intact. All eight wing attachment bolts were found, and each bolt was securing its respective bathtub fitting. All the flight controls were identified, but control continuity could not be confirmed because of the extensive damage. The landing gear and the flaps were determined to be in the up position. The elevator trim actuator was intact and set at a 1 1/2-degree nose-down setting, a setting consistent with a power-on cruise descent.

1.12.2 Aircraft Engines and Propellers

Both engines had separated from the aircraft. The propellers were extensively damaged on impact and separated from the engines. None of these components was fire-damaged; they were retrieved and sent to the TSB Engineering Branch in Ottawa for detailed examination. The engines were disassembled, and no pre-impact discrepancies were noted. The engine components tested did not disclose any malfunction that could have affected the operation of the engines. The damage sustained by the propellers was consistent with the propellers operating at high speed on impact. The pre-impact blade pitch position could not be determined.

An engine-driven fuel pump and a fuel return pump were recovered from the accident site at a later date, after snow had melted at the accident site. These components were forwarded to the TSB Engineering Branch for examination. The examination of the two pumps did not identify any pre-impact faults. The filter elements were found acceptably clean. The two pumps were functional at the time of impact, and the engine-driven fuel pump was being driven at the time of the first impact.

1.12.3 Instrument Examination

A number of flight and engine instruments were examined in detail at the TSB Engineering Branch. The following values were determined to be reliable instrument indications at the time of impact.

1. Captain's airspeed indicator - 137 knots

2. Captain's altimeter
   (a) altimeter setting - 29.85 in. Hg
   (b) altitude indication - 1,690 feet asl

3. Co-pilot's altimeter
   (a) altimeter setting - 29.88 in. Hg
   (b) altitude indication - inconclusive, but likely between 1,500 and 2,000 feet

4. Altitude alerter setting - 2,800 feet

5. Radio altimeter
   (a) pointer indication - 0 feet
   (b) decision height (DH) bug setting - 500 feet

6. Attitude direction indicator (ADI)
   (a) pitch attitude 2 to 4 degrees nose down
   (b) warning flags captured out of view

7. Captain's horizontal situation indicator (HSI)
   (a) digital course display - 251 degrees
   (b) heading marker - 253 degrees
   (c) course arrow - 250 degrees
   (d) magnetic heading - 215 degrees
   (e) bearing pointer - 225 degrees
   (f) heading warning flag captured out of view

8. Captain's radio magnetic indicator (RMI) - magnetic heading 208 degrees

9. Co-pilot's RMI - magnetic heading 215 degrees

10. Left engine instruments
    (a) torquemeter - 700 foot-pounds (ft-lbs)
    (b) propeller rpm - 1,800 rpm
    (c) oil pressure - at least 15 pounds per square inch (psi)

11. Right engine instruments
    (a) Gas generator rpm - 70 to 72 per cent
    (b) oil pressure gauge - 80 psi

12. The two VHF navigation receivers were set at navigation frequency 113.00 MHz.

13. One VHF radio was set at communication frequency 126.70 MHz and the other VHF radio was set at communication frequency 122.80 MHz.

14. One LF/MF automatic direction finder (ADF) navigation receiver was set at navigation frequency 335 kHz.

1.12.4 Light Bulb Examination

The annunciator panel, part of the autopilot annunciator panel assembly, and a map reading light assembly were recovered and examined. It was determined that the autopilot fail annunciator light was illuminated at impact. The marker beacon lamp identified as 'A' (airways) was considered to have failed while illuminated during service prior to the accident. The remaining lamps were considered to be off at impact.

1.13 Medical Information

Autopsies indicated that the occupants died from multiple and severe injuries sustained during the crash sequence. No medical condition was found that might have contributed to the accident. Toxicological examinations performed by Health and Welfare Canada's Civil Aviation Medical Unit (CAMU) were negative other than for a slight trace of an antihistamine found in one of the paramedics. This trace level was considered to be insignificant.

1.14 Fire

Post-impact fire destroyed the main fuselage section, although the empennage sustained very little fire damage. There was no evidence of pre-impact fire.

1.15 Survival Aspects

1.15.1 Search and Rescue

The emergency locator transmitter (ELT) activated on impact, but the antenna was destroyed during the crash. Search and Rescue was initiated by the airport manager; Search and Rescue personnel from Trenton, Ontario arrived at the accident site at 0145 EST on 30 November 1988.

1.15.2 Crash Survival

The four occupants were thrown clear of the aircraft on impact and were not burned. The captain and the two medical attendants remained attached to their seats by the lap belts. The captain and co-pilot seats were equipped with shoulder harnesses which were not being worn. The co-pilot was found near his seat with the seat-belt unbuckled and intact; it was determined that the seat-belt had not been buckled when the

aircraft crashed. The four seats had separated from either the floor attachment points or at the seat attachment joints. Because of the magnitude of the deceleration forces, the accident was not survivable.

1.16 Tests and Research

1.16.1 Fuel and Oil Analysis

Fuel and oil samples were taken from the engines and sent to the Fuels and Lubricants Division of the National Research Council for analysis. The results indicated that both fuel samples marginally failed the distillation analysis; however, when compared to a chromatogram of a typical wide-cut turbine fuel, both samples showed a lack of lower boiling point, which may have been caused by heat or weathering of the fuel. Infra-red spectra of the two oil samples were identical and typical of that of a synthetic ester turbine lubricant.

1.17 Additional Information

1.17.1 Chapleau Airport Instrument Approach

Chapleau Airport has a Transport Canada published NDB approach procedure (see APPENDIX B). The approach chart stipulates that the minimum safe altitude within 25 miles of the Chapleau NDB, when approaching from the northeast quadrant, is 3,000 feet asl. The minimum procedure turn altitude within nine miles of the Chapleau NDB is 2,900 feet asl. For this category of aircraft, the minimum circling altitude for the two runways is 2,000 feet asl or 535 feet agl, with a minimum visibility of 1 1/2 miles.

The published approach procedure includes direction to broadcast intentions on the ATF, 122.8 MHz, five minutes prior to commencing the approach.

The published instrument approach procedure depicted a 1,615-foot asl obstacle just to the left of the final approach course. During the investigation, it was determined that this obstacle was located to the right of the final approach course.

1.17.2 Communications Procedures at Uncontrolled Airports

Air Navigation Order (ANO) Series V, No. 11 requires that pilots operating aircraft under IFR and intending to conduct an approach at an uncontrolled aerodrome shall, unless otherwise directed by Air Traffic Control

(ATC), transmit on the appropriate frequency a directed or broadcast report five minutes prior to the estimated time of commencing the approach, including in this report approach intentions and estimated time of landing.

The Aeronautical Information Publication (AIP) Canada further states that at uncontrolled aerodromes, pilots shall establish communications with air/ground facilities when advised by ATC if in direct communication with an area control centre or terminal control unit, or otherwise, not later than five minutes prior to commencing the approach.

1.17.3 Altimeter Errors

A correct altimeter indication of an aircraft's altitude above sea level is dependent on an appropriate altimeter setting on the altimeter subscale. Normally the subscale is set to the station pressure of the nearest reporting airport. Each .01 inch of difference between the subscale setting and the correct altimeter setting results in a 10-foot error between the altimeter indication and actual aircraft altitude. If the altimeter setting on the subscale is higher than station pressure, the altimeter indication is higher than the aircraft's true altitude.

Low ambient temperatures result in altimeter indications that are higher than the true altitude of the aircraft. The magnitude of this temperature-induced error is approximately four per cent of the indicated altitude for every 11 degrees that the average temperature of the air column between the aircraft and the ground differs from the average temperature of the Standard Atmosphere (15 degrees Celsius at sea level, decreasing by two degrees Celsius for each 1,000 feet asl). To compensate for this altimeter error, pilots must apply temperature corrections to published procedure altitudes to ensure adequate obstacle clearance. Appropriate correction values for various temperatures and altitudes are published in tabular form in the Canada Air Pilot (CAP).

1.17.4 Cockpit Resource Management

Multi-crew aircraft operations are founded on the premise that flight deck duties will be shared by the flight crew members, thus permitting effective use of available human resources. A coordinated approach by crew members is essential to safe and successful operations. In two-person crew operations, the pilot not flying is normally responsible for monitoring the

actions of the pilot flying. Whenever there are significant deviations in altitude, attitude, navigation, etc., the pilot not flying is expected to advise the pilot flying in order to prevent an unsafe situation from developing.

Increasingly, the aviation community is recognizing the need for formal training for flight crews to enhance their understanding and skills in interpersonal communications, crew coordination and the management of all resources in the cockpit. Over the past few years, various airlines and aviation organizations have been training their pilots in this area which has come to be known as cockpit resource management (CRM). Neither crew member of the accident aircraft had received CRM training, nor is any required by Transport Canada.

2.0 ANALYSIS

2.1 Introduction

The aircraft struck terrain while in wings-level flight in a slight descent, 2.8 miles northeast of the Chapleau NDB. Ground elevation at the point of first impact was about 1,600 feet asl, 1,400 feet below both the MEA for the applicable air route and the published minimum safe altitude within 25 miles of the Chapleau NDB for the applicable quadrant.

Examination of the wreckage did not reveal any pre-impact failure of any aircraft system. There was no evidence of a pre-impact fire, and both engines were operating at impact. The flaps and landing gear were in the retracted position, and the elevator trim setting was consistent with a cruise descent. Communications with the crew had been normal throughout the flight. No in-flight difficulties of any kind had been reported by the crew. The final transmission from the crew appeared to have been cut off in mid-sentence by ground impact.

The aircraft was configured for an en route descent at a speed consistent with the initial approach to the NDB. The communications and navigation systems were set up for the NDB approach at Chapleau. The altitude alerter and radar altimeter were set consistent with the procedure turn altitude and minima respectively. Both pilots were qualified to operate as flight crew of a MEDEVAC flight in a Beech King Air A-100.

It is concluded that the crew inadvertently descended into terrain while in controlled flight, and the analysis examines possible explanations.

2.2 Pitot Static System Anomalies

As the captain had flown the same aircraft from Sioux Lookout to Timmins earlier that day and had not reported any difficulties, there is no reason to suspect a pre-existing altimeter system malfunction. Had there been a pitot or static source blockage, then anomalies would have been present in the airspeed indications; the pilots gave no indication to ATC of any such problem prior to their last transmission. Additionally, an external examination of the aircraft would have been conducted and flight instruments checked during normal ground checks prior to flight.

There is an alternate static source available in the event of pitot static failure; however, because of the post-impact fire, it was not possible to determine the position of the alternate source switch.

2.3 Altimeter Errors

The captain's and co-pilot's altimeters were found set to 29.85 and 29.88 respectively. The Chapleau altimeter setting after the accident was 29.76, a difference of .09 from the captain's altimeter and .12 from the co-pilot's altimeter. Thus, at the time of the accident, the captain's and co-pilot's altimeters could have been indicating 90 feet high and 120 feet high respectively.

At the time of the accident, the surface temperature was minus 12 degrees Celsius, about 25 degrees below Standard. Temperatures aloft were also below Standard, although to a lessor extent because of the approach of the warm front. The average temperature in the column of air between the aircraft and the ground was, therefore, less than 25 degrees below Standard. Thus, the true altitude of the aircraft would have been about eight per cent below the altitude indicated on the aircraft altimeters.

It is possible that the pilots did not apply a temperature correction when descending for the approach at Chapleau. If the crew had descended to the minimum safe altitude of 3,000 feet asl within 25 miles while approaching the Chapleau NDB, the aircraft could have been as much as 200 feet below the altitude indicated by the altimeters.

Coupled with the lower true altitude caused by differences in station pressure and the captain's and co-pilot's altimeter settings, the aircraft may have been up to 300 feet below that indicated on the aircraft altimeters. However, this difference between indicated and true altitude is insufficient to account for the aircraft's striking terrain 1,400 below the published minimum safe altitude.

2.4 Pilot Distraction

The crew may, for unknown reasons, have become distracted during the descent to the Chapleau NDB and unknowingly descended below the appropriate minimum altitude.

The altitude alerter was found set at 2,800 feet, 100 feet below the published procedure turn altitude for the approach to the Chapleau airport. This should have provided the crew with an aural and visual alert as the aircraft approached 2,800 feet in the descent from cruising altitude, and again as the aircraft descended below 2,800 feet. In addition, the alert pointer of the radar altimeter was found set at 500 feet. The radar altimeter should have given the crew a further warning that the aircraft was within 500 feet of the terrain.

Thus, if the descent below the published minimum altitude and into terrain was the result of distraction, the distraction was sufficient for both pilots to have missed the light and aural warning of the altitude alerter system and the visual warning associated with the radar altimeter.

It was determined that the autopilot fail light was illuminated at impact. This light illuminates when power is lost to the autopilot or when the autopilot gyro or servo monitor fails. The light being on at impact suggests that the autopilot may have failed in flight. Alternatively, it is possible that the light illuminated during the break-up sequence.

If the autopilot was in use while approaching Chapleau and it did fail in flight, it is possible that the crew was distracted by its failure or that they were relying on it to maintain their minimum safe altitude while attempting to acquire the airport visually. However, other evidence indicates that it would have been unusual for the captain to have used the autopilot during the descent, especially in poor visibility at an unfamiliar airport.

No source of distraction beyond the normal activities associated with the conduct of an IFR approach was identified during the investigation.

In conclusion, had the flight crew been distracted while approaching the NDB, warnings given by the altitude alert system and the radar altimeter should have alerted the crew to their descent below the appropriate altitude. Although it is possible that the crew became sufficiently distracted to have missed these cues and unintentionally descended below the published minimum altitude, no source of distraction was identified.

Notwithstanding the above, at the time of the accident there was a cloud ceiling likely between 700 and 1,000 feet agl. In addition, visibility was restricted in

snow showers; it may have been as low as two miles. These weather conditions, coupled with darkness and a lack of ground lights in the vicinity of the accident site, make it unlikely that the crew would have been able to see the ground in time to arrest the descent.

2.5 En Route Approach

The aircraft struck terrain about two miles to the right of AR16 on the direct track between the airport and the Chapleau NDB, and on a heading of approximately 212 degrees, close to the reciprocal of the track from the NDB to the airport. The location of the accident site and the direction of flight suggest that the crew may have intentionally deviated from the published air route to track over the airport toward the NDB, and commenced a descent in anticipation of acquiring the airport visually; this would have eliminated the requirement to conduct the full approach. Such action, if successful, would have expedited the evacuation of the patient; normal MEDEVAC flight practice is to avoid unnecessary delay.

The last reported weather available to the crew indicated a cloud ceiling of 1,000 feet and eight miles visibility. Thus, the crew should not have anticipated acquiring visual contact with the ground and airport above 2,500 feet asl; the published minimum safe altitude within 25 miles of the Chapleau NDB when approaching from the northeast is 3,000 feet asl. However, by the time the aircraft arrived at Chapleau, the Chapleau weather information was two hours old. The absence of current weather information would have provided further incentive for the crew to descend to the published minimum safe altitude near the airport, in the hope that the weather had improved sufficiently to permit a visual approach to the airport.

In fact, at the time of the accident, as indicated in the forecasts available to the crew, weather conditions had deteriorated from those in the last report. Although no official weather observation was available until two hours after the accident, witness accounts and the post-accident weather observation indicate that visibility was about two miles and the ceiling was near 700 feet. Therefore, for such an exercise to have been successful, it would have been necessary for the crew to intentionally descend to about 2,200 feet asl, 800 feet below the applicable minimum IFR altitude, and only 700 feet above the ground.

Given that the aircraft was on the track between the airport and the NDB and was close to the airport, and that the published minimum descent altitude for the approach was 2,000 feet asl, the crew may have decided that it was safe to descend below 3,000 feet asl, believing that they would sight the airport and be able to complete a visual approach.

During the descent from cruising altitude, distance information from the Timmins DME would have enabled the crew to determine their approximate position from the Chapleau airport. However, DME information would have been lost as they descended nearer the ground, and they may have unknowingly overflown the airport while still in cloud.

Although the above scenario is possible, the captain's record reflects a pilot who adhered to the rules of the air and displayed good airmanship and his check-rides indicate good knowledge of and compliance with established procedures. Moreover, with a new co-pilot, it would be unlikely that he would have cut corners or deviated substantially from established company procedures, particularly on what was his first flight into the Chapleau Airport. Thus, although it could be expected that the captain would deviate from AR16 to overfly the airport and descend to 3,000 feet asl, it is difficult to believe that, given the prevailing circumstances, he would intentionally descend significantly below the applicable minimum altitude.

2.6 Altitude Monitoring/Crew Coordination

Regardless of the reasons the crew descended below the published minimum safe altitude, it is reasonable to infer from the evidence that neither crew member was ensuring that there was sufficient ground clearance during the final moments of flight. Consequently, neither crew member was aware that the aircraft was descending into terrain.

Both pilots may have been looking outside the aircraft attempting to sight the airport and may not have been aware of the altimeter indication; in that case, they would not have realized that they had descended dangerously close to the ground. Because of the weather conditions, darkness, and the absence of ground lights, it is unlikely that there was any visual warning in time to prevent a collision with the terrain.

The circumstances of this accident highlight the need for coordination between flight crew members and the

importance of the effective use of all available resources. Coordination between the two pilots may have been inadequate during the descent to the Chapleau NDB. If the flight deck duties had been appropriately coordinated and shared by the pilots, one would have been monitoring the altitude and been able to warn the other as the descent continued; thus the accident should have been prevented.

2.7 Conclusions Regarding the Descent

There are many possible explanations for the controlled descent into terrain, but very little hard evidence to support a particular conclusion.

It could be that the descent was being monitored by only one of the pilots, who did an inadequate job for whatever reason, while the other was looking for the ground.

There is the possibility that both pilots saw cues, inside or outside the aircraft, which resulted in a degree of spatial disorientation. The pilots may then have thought that they were at a safe altitude. Because of the darkness and reduced visibility in snow, it is unlikely, however, that the pilots could see anything but snow outside the aircraft, even when they were close to the ground.

There are a few possibilities regarding the pilots' perception of the height of the aircraft with respect to the height of the terrain. Misreading of minimum altitude information from the charts or passing of misread minimum altitude information from one pilot to the other may have occurred with the result that the pilots were descending to the desired altitude, albeit the wrong one. The same logic can be applied to terrain elevation, in that they may have been purposely descending to an altitude that they both believed would provide terrain clearance. It is also a possibility that if one of the pilots was monitoring the altitude, he misread the altimeter and provided incorrect information to the other pilot.

Distractions could have played a part, but nothing has been identified as a distraction other than the fact that the autopilot fail light was illuminated at impact. No firm conclusions could be drawn from the fact that the light was on.

In conclusion, it could not be determined why the crew allowed the aircraft to descend, in controlled flight, into the ground.

2.8 Communications

At 2252 EST, the flight was cleared for the approach to the Chapleau Airport and instructed to contact the Chapleau ATF. The airport manager reported that he arrived at the airport shortly after 2200 EST and maintained a constant listening watch on the Chapleau ATF. No radio call from the aircraft was received until 2300 EST, after the airport manager called the aircraft when he heard it fly over the airport. Thus it appears that the crew did not comply with the instructions of ATC, the requirements of ANO V, No. 11, regarding the initial contact procedures for arrival at an uncontrolled airport, and the communications procedures published on the Chapleau approach plate. It would be a normal action on the part of the crew to contact the Chapleau ATF. Not only was it required, but such action would have been natural given that the latest weather information the crew had was two hours old and they had no information on the airfield conditions. Clearly, it would have been prudent, and a natural desire on the part of the crew, to obtain the latest information available regarding weather conditions and the status of the airport.

No reason could be found to explain the crew's failure to contact the Chapleau ATF. Although the airport manager reported that he maintained a constant listening watch, it is possible that the crew did transmit their intentions on the ATF and that the transmission was not heard by the airport manager.

2.9 Absence of Flight Recorders

The investigation of this accident was hampered by the absence of an FDR or CVR. In particular, the absence of a CVR prevented a more detailed assessment of the flight crew's decision making, coordination and other human performance issues, and their respective role in the accident.

3.0 CONCLUSIONS

3.1 Findings

1. The flight crew was certified and qualified for the flight in accordance with existing regulations.

2. The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

3. The autopilot fail light was illuminated at impact.

4. The weight and centre of gravity were within the prescribed limits.

5. There were no physiological or toxicological factors which would have adversely affected the performance of the flight crew.

6. There was no evidence to indicate that the crew transmitted their approach intentions on the Chapleau ATF; notice of intent should be made five minutes prior to the estimated time of commencing the approach.

7. By unofficial observation, there was a cloud ceiling of about 700 feet with visibility about two miles in snow at the time of the accident.

8. The crew descended below the applicable minimum IFR altitude while approaching the Chapleau NDB.

9. It could not be determined why the crew descended below the applicable minimum IFR altitude.

10. The aircraft struck terrain 1,400 feet below the applicable minimum IFR altitude in level, controlled flight.

11. Neither flight crew member was wearing his shoulder harness, nor was the co-pilot wearing his lap belt.

12. The investigation of this accident was hampered by the absence of a FDR or CVR.

13. The published NDB instrument approach procedure for the Chapleau Airport erroneously depicted the position of an obstacle adjacent to the final approach course.

3.2 Causes

The flight crew descended below the minimum applicable IFR altitude while approaching the Chapleau NDB. It could not be determined why the crew allowed the aircraft to descend, in controlled flight, into the ground.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1 Instrument Approach Procedure

During the investigation, it was discovered that the Chapleau non-directional beacon (NDB A) approach procedure in the Canada Air Pilot (CAP) depicted an obstacle just to the left of the final approach path, whereas the obstacle was actually located slightly to the right side of the on course. Although the error was not serious and certainly not causal to this accident, it did have the potential to contribute to a future accident. Therefore, an Aviation Safety Advisory was issued to Transport Canada suggesting that the approach plate be amended.

According to criteria in the "Canadian Government Specifications for the Transport Canada Aeronautical Information Publication" and in the "Department of National Defence Flight Information Publication and Terminal Instrument Procedures", the depiction of such obstacles is optional. Transport Canada amended the approach plate in May 1989 by deleting the depiction of the obstacle.

4.1.2 Cockpit Resource Management

Breakdowns in intra-cockpit communication and coordination have played an underlying role in many aviation accidents; in this case, apparently, neither pilot was monitoring altitude. Cockpit resource management (CRM) training has been increasingly recognized as a means of alleviating this problem, and, subsequent to a near flight-into-terrain incident near Prince George, British Columbia in 1987, the Canadian Aviation Safety Board (CASB) recommended that:

> The Department of Transport actively promote the adoption of Cockpit Resource Management training by commercial operators.
>
> CASB 90-53

It is noted that several Canadian carriers have adopted CRM as part of normal training for their pilots, and that Transport Canada will continue to actively promote the adoption of CRM training by all operators.

4.1.3 Ontario Air Ambulance Operations

Subsequent to this accident and three others involving Ministry of Health (MOH) aircraft, the Ministry contracted a consultant to study its Air Ambulance

operations. Later, revisions were made in the operations of both the MOH dedicated aircraft and in the Standing Offer for chartered aircraft. Among the changes are the equipping of all dedicated aircraft with cockpit voice recorder (CVR), giving preference to charter operators who have CVR-equipped aircraft, and the inclusion in the Standing Offer of specifications for an active flight safety program.

4.2 Action Required

4.2.1 Flight Recorders

Although standard investigative techniques enabled the Board to determine that a serviceable aircraft descended into the trees while in controlled flight, the underlying cause(s) of this accident will likely remain obscure. This case is one of many in which a flight data recorder (FDR) or a CVR could have provided information which would point to a cause(s) and an associated safety deficiency from which preventative measures could have been identified. In the years 1988 to 1989, 14 Canadian major air occurrences were investigated. Of these, five aircraft were equipped with recorders, providing vital information in two occurrences and simplifying the investigation of the other three. Nine aircraft were not equipped, and in five of these, a recorder could have provided information to assist in confirming the cause(s) and in developing safety action. The cause(s) in four cases, including this one, will likely remain uncertain because of a lack of information.

The present Canadian regulations for flight recorders were enacted in 1969, and since then, only editorial or administrative changes have been made. In 1985, the International Civil Aviation Organization (ICAO) issued new Standards and Recommended Practices (SARPS) for flight recorders. The existing Canadian legislation met the ICAO standard, but fell short of the Recommended Practice. Canada endorsed the SARPS and formed a Flight Recorder Standards Review Group in 1986. In November 1987, the CASB produced a Statement of Requirement (SOR) which advocated improved rules for flight recorders. Subsequent to consultation with the Canadian aviation industry, Transport Canada stated their intention to issue new legislation which would correspond as closely as possible to U.S. rules issued in July 1988.

These rules, and thus the planned Canadian legislation do not meet all of the ICAO Recommendations nor those of the CASB SOR; nevertheless, they do offer a significant improvement over the existing Canadian

rules. CVRs would be required in more of the smaller aircraft that are widely used by small air carriers. Also, CVRs would be required in many helicopters, and both CVRs and FDRs would be mandatory for large, passenger-carrying helicopters.

Better recorder technology, such as a solid-state digital CVR with a potential for two-hour capacity, will soon be available, and agencies such as EUROCAE (European Organization for Civil Aviation Electronics) are considering rule changes to take advantage of these new capabilities. However, as indicated above, new rules are needed in the near-term to provide information that may be necessary for safety investigations and effective corrective measures. Therefore, despite the limitations of the proposed legislation and the prospect of better hardware to come, the TSB recommends that, in the interim,

> The Department of Transport expedite legislation for upgrading the flight recorder requirements for Canadian-registered aircraft.
>
> (A91-13)

4.3 Safety Concerns

4.3.1 Air Ambulance Services

The use of aircraft as ambulances is a specialized aviation operation which has expanded rapidly during the past decade. Perceived public concern regarding the safety of such operations in Ontario lead the Ontario MOH to commission a review of the Air Ambulance Service in Ontario. On a Canada-wide basis, the TSB is also gathering data. This information will be analyzed to identify areas in which the safety of Air Ambulance Services can be improved.

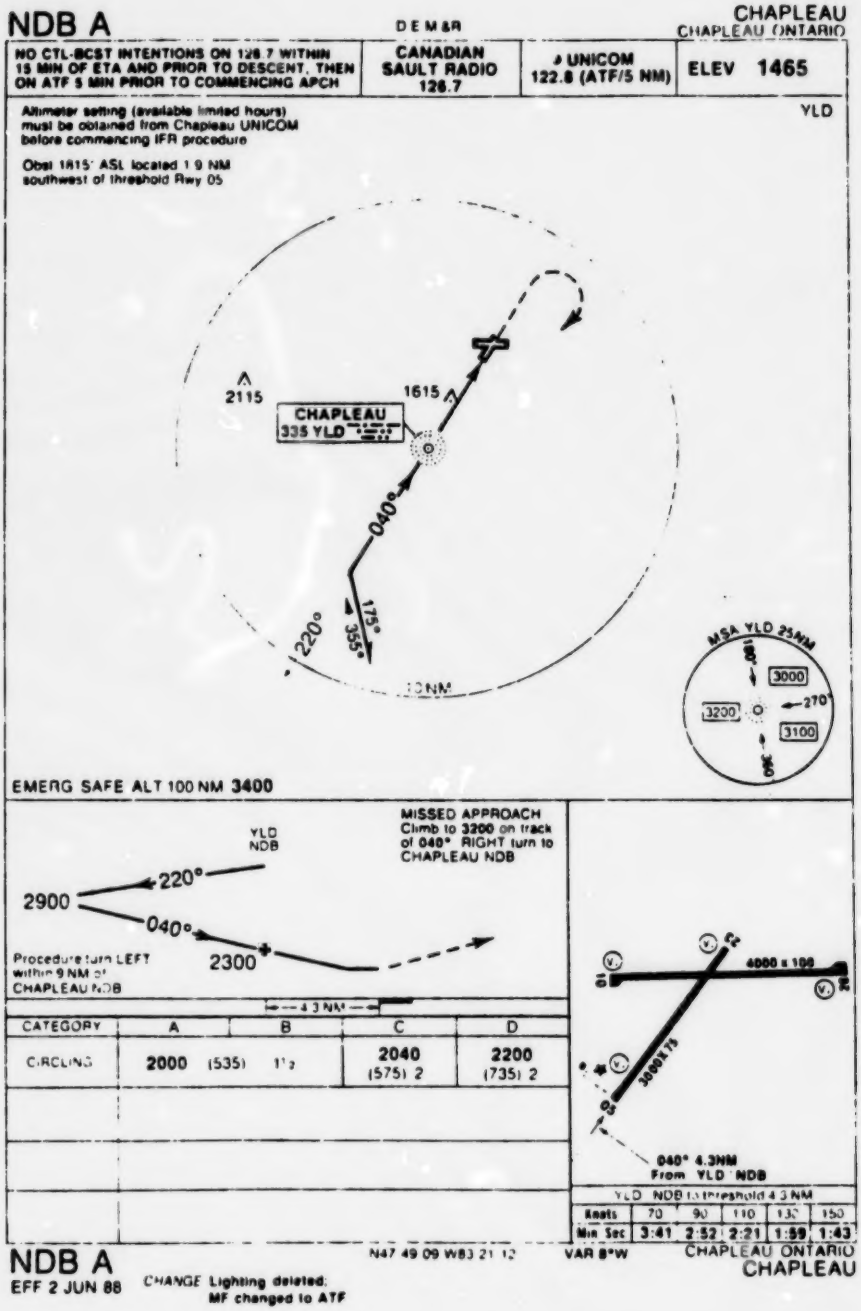
4.3.2 Use of Shoulder Harness

A 1987 CASB Safety Study concluded that 90 per cent of aircraft occupants would receive significantly reduced injuries by using a shoulder harness, and that 80 per cent of small-aircraft pilots wear a shoulder harness when available. In this accident, both of the cockpit seats of the aircraft were equipped with a shoulder harness; however, neither was in use on impact. This accident was not survivable because of the magnitude of the impact forces; however, it is disturbing that two professional pilots were not wearing the available shoulder harness during an approach.

This report and the safety action therein have been adopted by the Chairman, J.W. Stants, and Board Members.

Chapleau Airport Instrument Approach Chart

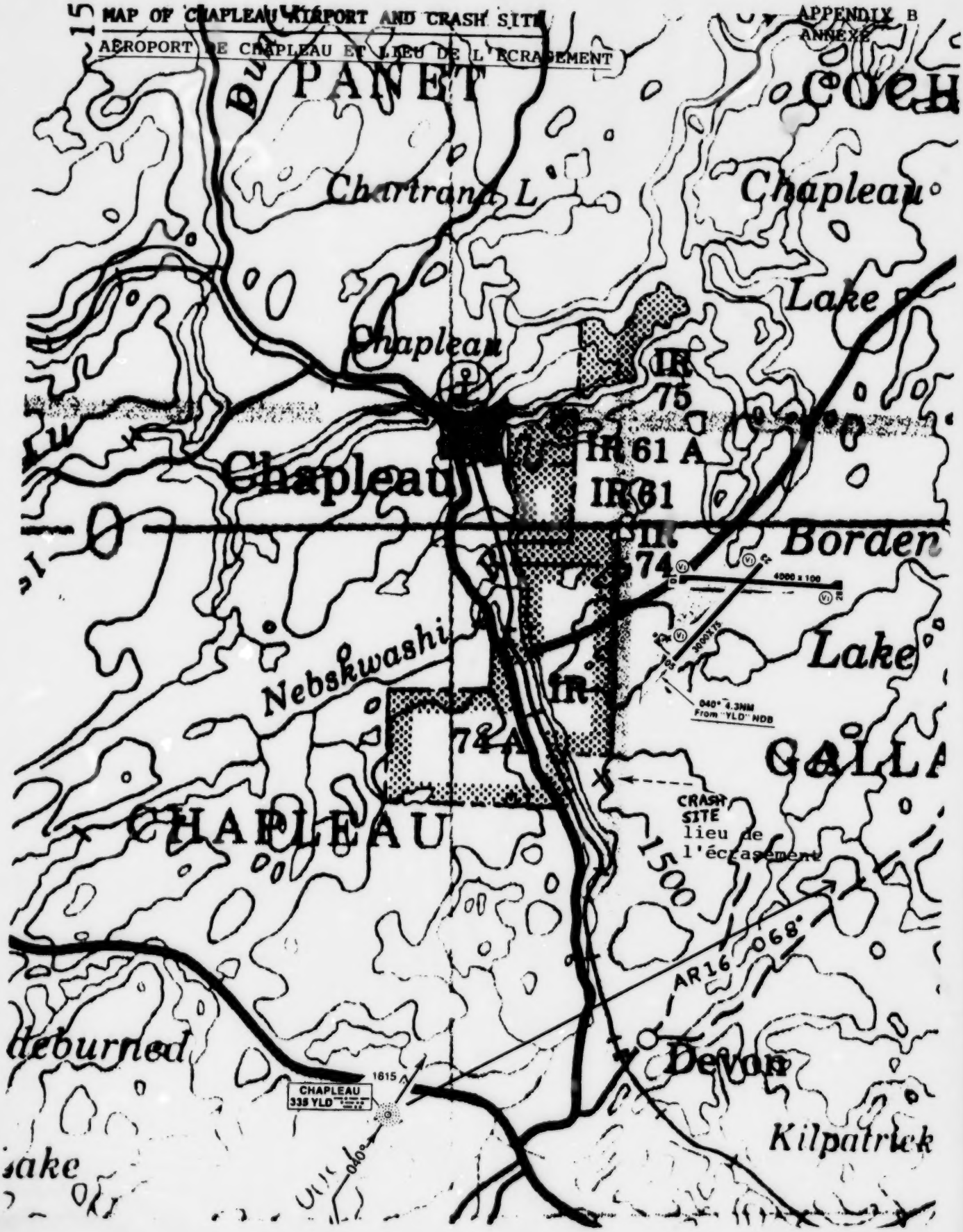
Carte d'approche aux instruments - Aéroport de Chapleau



MAP OF CHAPLEAU AIRPORT AND CRASH SITE

AÉROPORT DE CHAPLEAU ET LIEU DE L'ÉCRASEMENT

APPENDIX B
ANNEXE



APPENDIX C

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 2/89	Engines/propellers Examination
LP 95/89	Main Fuel Pump
LP 177/88	Light Bulb Analysis
LP 178/88	Instrument Analysis

These reports are available upon request from the Transportation Safety Board of Canada.

GLOSSARY

ADF	automatic direction finder
ADI	attitude direction indicator
agl	above ground level
AIP	Aeronautical Information Publication
ANO	Air Navigation Order
AR	air route
asl	above sea level
ATC	air traffic control
ATF	aerodrome traffic frequency
CAMU	Civil Aviation Medical Unit
CAP	Canada Air Pilot
CASB	Canada Aviation Safety Board
CRM	cockpit resource management
CVR	cockpit voice recorder
DME	distance measuring equipment
ELT	emergency locator transmitter
EST	eastern standard time
EUROCAE	European Organization for Civil Aviation Electronics
FDR	flight data recorder
ft-lb	foot-pound
FSS	flight service station
hr	hour(s)
HSI	horizontal situation indicator
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
in. Hg	inches of mercury
kHz	kilohertz
lb	pound(s)
MEA	minimum enroute altitude
MEDEVAC	medical evacuation
MHz	megahertz
MOH	Ministry of Health
N	north
NDB	non-directional beacon
nm	nautical mile(s)
PPC	pilot proficiency check
psi	pounds per square inch

APPENDIX D

GLOSSARY

RMI	radio magnetic indicator
rpm	revolutions per minute
SARPS	Standards and Recommended Practices
SOR	statement of requirement
TSB	Transportation Safety Board of Canada
UHF	ultra high frequency
UNICOM	Universal Communications
UTC	Coordinated Universal Time
VHF	very high frequency
VHF/DF	very high frequency/direction finder
VHF/FM	very high frequency/frequency modulated
VOR	very high frequency omni-directional range
W	west
°	degree(s)
'	minute(s)